

The year of Commercial Crew

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Re-engining competitors vie to keep these U.S. nuclear, conventional workhorses flying past 2050 **PAGE 24**

COUNTDOWN TO COMMERCIAL CREW



Boeing and SpaceX are poised to make 2019 the breakthrough year in the nearly decadelong effort to get the U.S. back in the business of launching astronauts to the space station and bringing them home. **Amanda Miller** looks at the stakes and steps ahead for the Commercial Crew program.

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SpaceX moved its Crew Dragon capsule and a Falcon 9 rocket to Launch Complex 39A at Kennedy Space Center in January to prepare for the planned crewless test mission to the International Space Station under NASA's Commercial Crew program. This photo was taken during a dry run and shows the access bridge that astronauts will someday walk across to access Crew Dragon.

SpaceX

The passengers queuing up on the platform include a scientist, a business mogul, a politician. They're privileged pioneers — private citizens prepared to rumble away on one of the newfangled conveyances that the transportation tycoons have

started selling tickets for.

And they've all been issued matching suits.

It's someday in the future. They climb aboard from a platform 60 meters off the ground. They're headed to a commercial hotel in Earth orbit, then on to their final destinations — public and private space stations and in-space manufacturing plants.

Depending on the ride they've chosen, they may or may not linger on the "crew access arm" for a last look at the Atlantic Ocean along Florida's Space Coast. The designs of these arms aren't equal; one company's may harken back to a windowless airline boarding ramp while another's evokes the helm of a yacht.

This year, 2019, is supposed to be when NASA's combined \$8.2 billion in grants under the 9-year-old Commercial Crew program — largely to Boeing and SpaceX — starts to pay off. The first crew launches by these companies would be a small step toward that futuristic vision and a big step toward liberating NASA from the Russian Soyuz capsules it has relied on to carry its astronauts to and from the International Space Station since 2011, when it retired the space shuttle fleet.

If the year brings a breakthrough, it will come two years later than planned and on the heels of a close call with tragedy in October, when a U.S. astronaut and cosmonaut made a hair-raising emergency Soyuz landing shortly after launch. By that time, the U.S. was not supposed to have needed a ride on a Soyuz. The companies had initially said that by 2017 they could get their respective spacecraft certified by NASA for human flight.

"If there are further delays," NASA associate administrator Steve Jurczyk told me in November, before the U.S. government shutdown, "we might have to buy one or more Soyuz seats for more time." The Government Accountability Office, in a 2018 report, "Plan Needed to Ensure Uninterrupted Access to the International Space Station," stated that NASA had contracted for seats on Soyuz spacecraft through a November 2019 return flight.

"The plan was always, when SpaceX and Boeing put their capability in place that we would discontinue buying Soyuz seats from Russia," Jurczyk said.

If all goes well, however, Boeing and SpaceX will take the final, critical steps this year toward earning NASA's human-rating certification for passenger spaceflight. This requires a number of

benchmarks, including showing a “loss of crew” probability of 1 in 270 or lower. Each company must launch an unmanned version of its seven-person capsule to the space station, followed by a flight with a crew of two in SpaceX’s case and three in Boeing’s case. SpaceX plans to send its first capsule to the station no earlier than February, followed by the first crew launch in June. Boeing is targeting its first station launch for March on a United Launch Alliance Atlas 5 rocket followed by the first launch with a crew in August.

NASA has paid for much of the two capsules’ development. But unlike in the past, the government won’t take over the controls once these spaceships are all set to go. Boeing and SpaceX get to keep their spacecraft.

As interested as NASA is in getting the U.S. flying to space again, the agency doesn’t want to forget the broader goal of establishing privately owned transportation to low Earth orbit. The thinking is that this could give a boost to those who envision creating privately owned space stations as the seeds of a vibrant economy in space.

“I know [the Commercial Crew contractors] are working with the companies, particularly Bigelow and Axiom, who have these plans for commercial laboratories, commercial hotels for space tourism, and how they could provide the transportation for those ventures,” Jurczyk said.

How we got here

At a meeting in Denver in December, at which industry executives described their work in the field of human spaceflight, Joe Rice, director of government relations for Lockheed Martin Space, put today’s scenario in perspective.

“Let me first impress upon you something that I think is a tragedy,” said Rice, a retired U.S. Army colonel who has taught college-level history. “Since the dawn of the Space Age, there have always been two nations that could put people into space — going back to the ’50s and the space race, always two nations that could put people into space. The Soviet Union and the United States — us. So today, this very day, there are still two nations that can put people into space, but the United States is not one of them,” he said, referring to China and Russia. “And that should shock us and bother us.”

As a staff member in the White House Office of Science and Technology Policy under President Barack Obama, Phil Larson worked closely with NASA to come up with the Commercial Crew plan as a follow-on to the George W. Bush administration’s Commercial Orbital Transportation Services program. COTS paid companies to develop their ideas for commercially operated delivery services to the ISS, for both cargo and crew.



▲ **NASA, Boeing and** United Launch Alliance practice prelaunch routines in the Boeing Mockup Trainer for the Starliner spacecraft in Houston.

NASA

▲▲ **NASA simulates** a land landing with a mock-up of the Boeing CST-100 Starliner spacecraft at NASA’s Langley Research Center in Hampton, Va.

NASA

The Commercial Crew program spun off COTS in 2010, outlining the specifics required for human transport. NASA’s \$8.2 billion for Commercial Crew is paid in increments, according to program milestones, while the companies also invested in the development. Larson, an expert on space politics and the assistant dean of the College of Engineering at the University of Colorado, thinks that the program will have been worth it even if the two capsules only manage to transport U.S. astronauts to the ISS. By reducing launch costs by “dimes on the dollar compared to what it was before,” NASA will have proved that it “works” for the government to act as a venture capitalist.

Commercial Crew was always supposed to be about more than just supplying an astronaut delivery service to the government. The chosen companies also committed to cultivating new commercial markets with their spacecraft — “and then the cost of further developing and operating those vehicles would be spread across a business base that was more than just NASA,” says Jurczyk.



Where things stand

Boeing engineers were readying a test vehicle for a test of Starliner's pad-abort escape system in White Sands, New Mexico, in early 2019, a delay following the discovery of a propellant leak in an earlier engine test. Meanwhile, the capsule for the company's first crewed launch was bound for Boeing's environmental test team in El Segundo, California. There, it would be exposed to simulated environments of launch and space and help to prove to NASA that it's safe for humans.

NASA astronaut Doug Hurley was one of the two astronauts selected to ride in a Crew Dragon on its first test flight with a crew. The former U.S. Marine Corps test pilot who piloted the space shuttle twice describes the preparations, in a NASA interview, as "relearning" all the procedures and techniques that go along with first-time missions on new spacecraft.

Both Starliner and Crew Dragon may look familiar. Starliner's shape harkens to the Apollo command module design, while Crew Dragon's spaceflight heritage is the cargo version that has flown 16 trips to the station and back. In fact, SpaceX's autonomous Dragon was the first private spacecraft to make a delivery to the ISS and back under a Commercial Resupply Services contract, NASA's earlier spinoff of COTS. That program has already resulted in nu-

merous commercial deliveries and gone through a second round of contract bids.

The first Crew Dragon headed for space was on the launchpad at Kennedy Space Center as of last month — the pad where the space shuttles launched. This first test flight to the ISS had been delayed twice since NASA started giving dates in November 2018, this time "to complete hardware testing and joint reviews," according to a NASA statement.

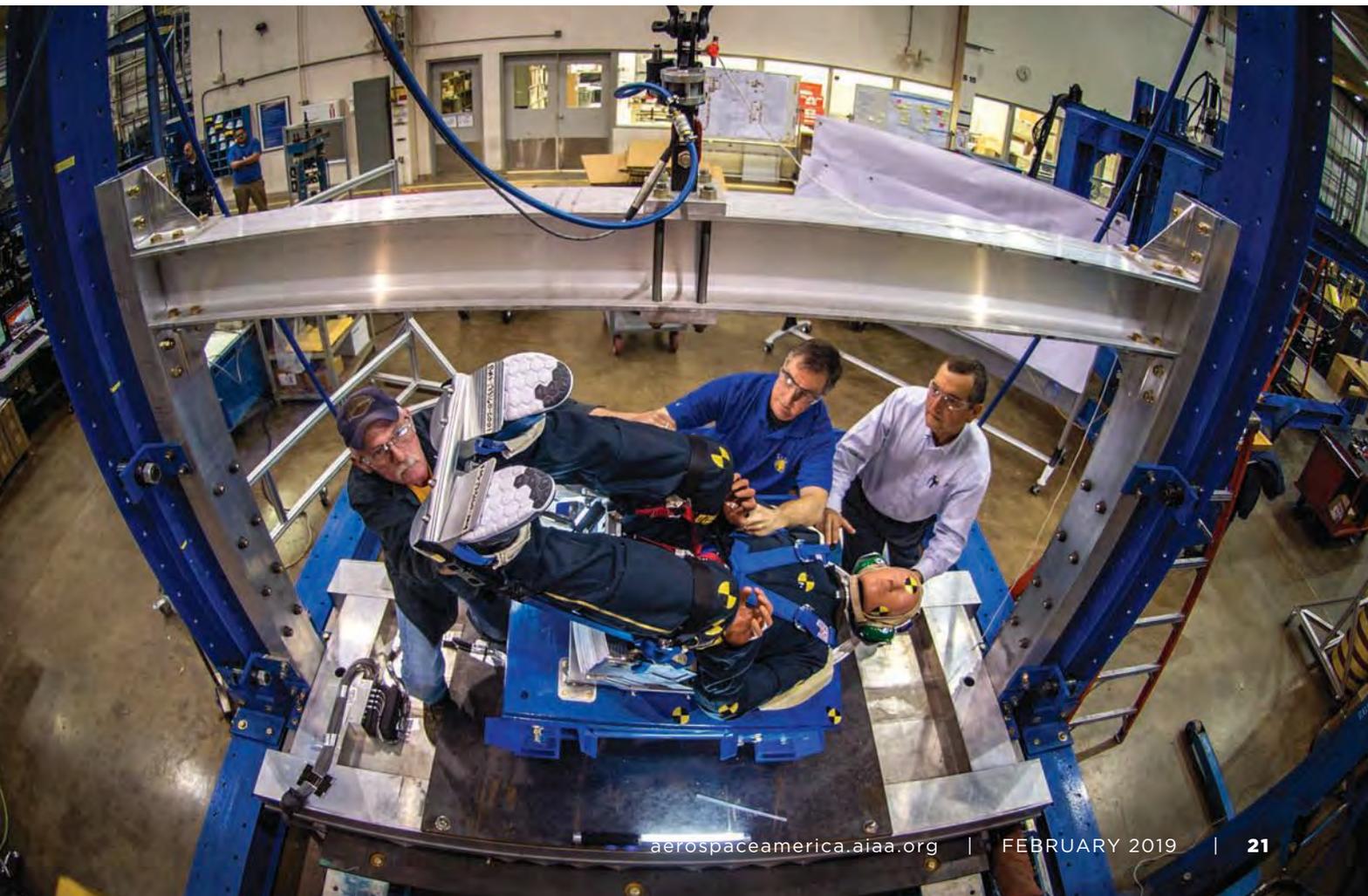
SpaceX will get astronauts to the ISS first, if the rest of NASA's launch timeline sticks, but only by a couple of months. Neither the SpaceX Falcon 9 design that will loft Crew Dragon nor the ULA Atlas 5 that will launch Starliner have ever carried people, which is why each must still be certified for human spaceflight.

ULA's Commercial Crew Program Manager Barb Egan said in late January that the Atlas 5 booster for Starliner's March test flight was ready for the launchpad and that the rest of the rocket was on schedule. A key addition to the human-rated Atlas 5 design is an emergency detection system to alert Starliner's flight computer if it needs to abort.

The crew won't manually fly either seven-person capsule. Both will be programmed to get to the space station, dock, then return to Earth autonomously, though astronauts can take over.

While the two spacecraft may seem familiar, the astronauts' personal gear is getting an outwardly

▼ **Engineers test the seat design** of Boeing's CST-100 Starliner in Mesa, Ariz.
NASA





LANDING TECHNIQUES

apparent update. Starliner's crew will wear bright "Boeing Blue" spacesuits for launch, ascent and re-entry. Dragon's crew will get tinted faceplates with sleek, white-and-gray suits that coordinate with the look of the pod.

Situation with Russia

In the context of ISS crew rotations, delays can add up in increments of \$80 million per flight. That's how much the Russian space agency, Roscosmos, charges to deliver U.S. astronauts back and forth in a Soyuz capsule, like the one in which the astronaut and cosmonaut had to abort in October.

Roscosmos' investigation found that during assembly, a pin was damaged on a sensor that controlled the separation of a booster. Both Crew Dragon and Starliner also will have the ability to separate from the rocket, fire engines to get away and land safely.

"Thank goodness the Russians put that capability in place eight or nine years ago for that scenario," says Jurczyk. "And it's challenging because that capability needs to work on the pad, when you're at zero speed, and then it needs to work when you're lower and slower in the atmosphere, and then it needs to work when you're higher in the upper atmosphere where it's less dense but you're going at a much higher speed."

Starliner cushions its hard-surface landing with bottom-side airbags. SpaceX originally proposed a thruster descent to put down Crew Dragon on dry land, but later opted for an ocean splashdown. SpaceX founder Elon Musk said in a January tweet that the company de-prioritized the thruster landing after concluding that Crew Dragon would never go to the moon or Mars, where it would need to make a soft landing on thrusters.

Boeing designed the Starliner's mission in 10-second increments and calculates the probability of successfully aborting at 95 percent.

NASA had hoped to receive all human rating data back in 2017. In the GAO report, the congressional watchdog laid responsibility for the delays partly on NASA for allegedly giving unclear instructions about how to calculate the probability that an astronaut will die or become permanently disabled, the factor called loss of crew; and pointed out that the close involvement of NASA had taken more time than the companies had expected.

The GAO recommended that NASA, meanwhile, consider alternatives to the Commercial Crew vehicles for getting U.S. astronauts to the orbiting lab.

What a win looks like

Getting astronaut launches back underway from the U.S. could help restore the U.S. "geopolitical soft power" that Ian Christensen of the Secure World Foundation says may have suffered by paying Russia to fly astronauts to the ISS.

Christensen views Commercial Crew as an important first step in seeding a new economy in low Earth orbit. He thinks the resilience inherent in having multiple providers is good for the long-term well-being of U.S. space efforts.

With Starliner and Crew Dragon on the verge of test flights, the industry is looking ahead to whether private passengers will start to get in line — and whether commercial spaceflight is even viable.

◀ **The SpaceX ship that** will recover the Crew Dragon spacecraft and astronauts after splashdown has a medical treatment facility and helipad. SpaceX

Now with Starliner and Crew Dragon on the verge of test flights, the industry is looking ahead to whether private passengers will start to get in line.

Success of Commercial Crew won't be just in the technological sense, but instead "in the business sense of who can sell their product in the marketplace," says Wayne Hale, a former space shuttle program manager and now a consultant on human rating for Boeing and United Launch Alliance.

Also a member of the NASA Advisory Council, Hale thinks it's "very likely" tourists will want to pay visits to the space station and that those may be internationally negotiable. He figures both the Star-

liner and Crew Dragon could go anywhere in low Earth orbit.

NASA's Jurczyk predicts astronauts from other countries' space programs will be the first to buy seats on a Crew Dragon or a Starliner but hopes the companies will also try to generate demand among the likes of Axiom Space, which has plans for a commercial space station, and Bigelow Aerospace, which plans to open a hotel.

Hale thinks SpaceX and Boeing have a shot at selling tickets and that right now, on the cusp of the first Commercial Crew test flights, the world could be about to witness a boom in space travel. He thinks the privileged few could swell by ten- to a hundred-fold in a decade.

Tommy Sanford, executive director of the Commercial Spaceflight Federation, compares the anticipated eclectic mix of private passengers with the first travelers to cross North America by railroad. They went to work in manufacturing, materials science, health and agriculture — the same kinds of things that will soon be done in orbit.

"One of the biggest barriers that researchers talk about is not having folks [in space] who are researchers and scientists working with the capability hands-on," Sanford says. "Who knows what are all the benefits that are bound to be gained from that?" ★

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